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Voluntary leg movement rhythm frequency correlates with maximal rate of isometric leg flexor force development in humans

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Introduction: Rhythmic movements like walking and cycling might depend upon spinal neural networks, termed central pattern generators. Human studies in the area are challenged since output from the networks cannot be directly measured as in animal studies. But, understanding can be enhanced via non-invasive studies. We investigated the role of rate of force development (RFD), representing a neuromuscular variable that e.g. is affected by the extent of facilitating descending supraspinal drive, on the frequency in voluntary rhythmic leg movement (FM), reflecting central pattern generator rhythm output. We hypothesized that RFD would positively correlate with FM.

Methods: Nine healthy subjects (8 men, 184±7 cm, 79±8 kg, 30±5 years) participated. RFD in the dominant leg was determined with the participant sitting on a cycle ergometer mounted with force pedals. The crank arm was fixed at 78° (0°=pedal in top position) before 10 voluntary isometric leg extensions were performed. Next, with the crank arm at 258°, 10 isometric leg flexions were performed. Muscle contractions were performed as fast and powerful as possible, sustained for 1-2 s, and separated by 15 s pauses. The non-dominant leg, which was not tested, rested passively on the other pedal. Tangential pedal force was recorded, and maximal RFD calculated across 25-50 ms periods, for all 20 muscle contractions. For each participant, average values were calculated separately for the 10 leg extensions and the 10 leg flexions. FM was determined as the average freely chosen cadence across 5 min of submaximal cycling at 100 W.

Results: Maximal RFD in isometric leg extension was 5,000±1,947 Ns^{-1} and ranged from 1,704-8,060 Ns^{-1}. In leg flexion, it was 3,910±1,687 Nms^{-1} and ranged from 1,115-6,079 Ns^{-1}. FM was 1.15±0.22 Hz and ranged from 0.74-1.40 Hz. Correlations showed: Maximal RFD in leg flexion (x) vs. FM (y): y=0.0001x+0.77, R^2=0.53, P=0.027. Maximal RFD in leg extension (x) vs. FM (y): y=0.00005x+0.90, R^2=0.19, P=0.240.

Discussion: Maximal RFD is influenced by, e.g., muscle size, muscle fiber type composition, Ca2+-kinetics, tendon stiffness, and neural activation. Descending supraspinal drive might affect both central pattern generator rhythm output (reflected in FM) and maximal RFD, and thus account for the positive correlation between the two latter variables. Maximal RFD in leg flexion, rather than in leg extension, was associated with freely chosen cadence, which might indicate that the leg flexor neuromuscular system is of particular relevance for setting the voluntarily chosen frequency in pedalling. To our knowledge, maximal RFD is the first inherent neuromuscular variable found to correlate with FM in humans.